# A Housing Energy Management Program Report

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# HIGH EFFICIENCY CONDENSING FURNACE FIELD STUDY FINAL REPORT

(PROJECT REPORT #38)

UNDERTAKEN JOINTLY BY
THE ONTARIO MINISTRY OF MUNICIPAL AFFAIRS AND HOUSING
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AND
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## SUMMARY

In co-operation with the Ontario Ministry of Municipal Affairs and Housing, and with additional funds provided by the Ministry of Energy, Union Gas Limited undertook to field test two "high efficiency" condensing natural gas furnaces. In testing this equipment, two sites were chosen which it was felt were representative of homes in Southwestern Ontario. The first location selected was a single storey bungalow over a full basement. With a calculated heat loss of some 13.2 KW, this 207 sq. m. home is typical of a great many of the houses built in the late 60's, early 70's. Equipped with a conventional natural gas furnace, this site (Site I) proved to be well suited for test purposes. The second location chosen was a single storey ranch style home built over an open/unheated crawl space. Constructed in 1970, this home covers some 179 sq. m., with a calculated heat loss of 21.69 KW. Perhaps uncommon however to other regions in the province, this site was equipped with a conventional oil furnace located in the unheated attached garage. This practise of locating the furnace in the garage, although perhaps not as common today, was once rather widely practised in this area.

As a comparative study, the procedure of these field tests involved the parallel operation of each of the conventional units to a condensing natural gas furnace. With the units connected in parallel, it was a simple matter to flip/flop operation between the furnaces on a pre-arranged schedule (given appropriate submetering, dampers and controls). In monitoring the installations, attention was given to recording total energy inputs with respect to ambient temperatures while maintaining fixed operating conditions (ie. set points, anticipator settings, air volumes, temperature rises and external static pressures).

With the study completed in the spring of 1983, this report addresses the results of the field trials with respect to operating performance and energy savings. For information as to the actual installation of the units and detailed site descriptions, the reader is referred to an earlier report, see reference 1.

From the installation and subsequent testing of the condensing equipment, several conclusions could be reached. In each instance , the condensing gas furnaces showed significant savings in terms of total energy. Although the electrical requirements of these furnaces were actually greater than the more conventional units (on a per Degree Day basis), these were largely offset by the fuel savings to give a total cumulative energy savings.

In comparison to the conventional gas unit, the high efficiency furnace at Site I had a projected energy savings of 24%

or an estimated **31% increase in seasonal efficiency**. This increase in efficiency suggests a seasonal efficiency of some 89% based on an assumed conventional efficiency (near the higher end of achievable values) of 68% for this site. Such a savings would represent an **annual dollar figure of $73** for Site I. Because however of the initial comparitively low consumption (55.9 GJ), these savings may not be enough to warrant the additional expense associated with the unit when one considers the payback as compared to installing a conventional gas furnace. For a more complete economic picture however, one should look at the entire life-cycle costs. Having done such an analysis, it is clear that the condensing gas furnace is a very positive investment. A discounted cost advantage of some 10 and 14% was found over oil and electricity respectively.

At the **oil site**, significant savings were realized in operating the condensing furnace. These savings were found to be **49% of the total energy used**, for a seasonal efficiency increase of 98%. The only available conclusion from these results is that the existing oil furnace must be operating substantially below the normally assumed value of 65% (likely in the order of 40%). The installation conditions and distribution system may be part of the answer. Aside from an exact seasonal efficiency, the results of the oil site are significant in that they indicate a large savings potential. This location for example could quite conceivably experience a **$1,550 annual savings** as compared with operating on oil. In a similar discounted cost analysis as for Site I, the condensing gas option at Site II was found to be 56 and 23% more economical as compared with oil and electricity over 15 years.

With the results as presented here, one may be confident in the **relative** increase in seasonal efficiencies of the condensing equipment with respect to the conventional furnaces. Exact efficiency values were however not an objective of this study and as such remain undetermined. Still, the savings as realized with this study are significant and should be considered. Specific savings for example of 0.105 cu. m/DD of gas and 1.064 l/DD of oil were experienced at the gas and oil sites respectively. This in turn equates to some 140.21 cu. m. and 1378 l over the test period; for projected annual savings of 372 cu. m. and 4312 l for sites I and II respectively. Finally one must be careful in extrapolating these results to other installations and locations (the oil site in particular). As with many comparative studies, these results are both house and site dependent and should be viewed as such.

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# 1.0 INTRODUCTION

## 1.1 AGREEMENT AND OBJECTIVES

Under contract with the Ontario Ministry of Municipal Affairs and Housing, Union Gas Ltd. has undertaken to field test two condensing gas furnaces. With the units installed, Union Gas has monitored their performance in an effort to gain operating results. The purpose then of this report is to summarize the results as collected this past heating season (82/83), and to evaluate the energy savings potential of the equipment itself.

In developing a methodology to use in comparing the performance of the high efficiency furnaces, a decision was made to operate the test units in parallel with a conventional gas (gas/gas) and oil (oil/gas) furnace respectively. For a detailed explanation and description of the test locations, the reader is referred to an earlier report entitled 'HIGH EFFICIENCY CONDENSING FURNACE FIELD STUDY -INSTALLATION REPORT-'(ref. 1). Published in December 1982, this report outlines the various installation considerations and early performance results of the two test locations.

In operating the two test sites, additional electric KWH and gas/oil meters were installed. Having recorded each input, one is then able to establish relative consumption histories as a function of ambient temperatures for each furnace. For this purpose, Atmospheric Canada mean daily temperature records were used to calculate actual degree day (DD) occurances.

## 1.2 FURNACE INSTALLATIONS

As earlier reported (ref. 1), very little added difficulty was experienced in the actual installation of the condensing units as might be compared to a conventional furnace. The only area where one may have reason for concern is in the venting of the appliance. In exhausting the products of combustion, attention must be given to both the equivalent feet requirements for the venting (as governed by the exhaust fan capacity and pressure switch differentials) and the location of the vent terminal itself. Only a minimal additional expense should result from these extra venting procedures. In some instances (ie. where the retrofit of a conventional furnace may require that the existing chimney be lined), the venting procedures of the condensing furnace may in fact be less expensive. For further specifics on the installation of the test furnaces, refer to the previously mentioned report.

## 2.0 OPERATING RESULTS

### 2.1 GENERAL COMMENTS

In both instances, each of the condensing furnaces operated satisfactorily in terms of maintaining comfort levels and overall performance. No incidence of nuisance shutoffs (ie. as may result from a blocked vent) or excessive condensation freeze up was experienced at either location. Some concern was expressed however in a slight increase in detectable noise, both from the venting of the exhaust and vibrations transmitted through the vent hangers. In each instance these noise levels were not, in the opinion of the homeowners, sufficient to discourage use of the furnaces.

Aside from these observations there were no indication of any corrosion on the heat exchangers of the condensing units. Although an extensive investigation of this was not done, other field experience suggests that corrosion of the exchangers is presently not a problem.

## 3.0 ENERGY FIGURES

### 3.1 COLLECTED DATA

Upon completion of the 1982/83 heating season, results of the high efficiency condensing gas furnace field trials were compiled. Tables 1 thru 4 (Page 4 & 5) contain the actual recorded results of the field testing and as such, represent the basis from which efficiency/savings comparisons will be made. With these results, one can begin to evaluate actual savings and efficiency comparisons. Before continuing with the development of the results there are several terms which need to be defined:

| | |
|---|---|
| PERIOD | operating schedule for the furnace in question (typically 7 days) |
| GAS | total gas energy input to the furnace over the specified period (megajoules) |
| ELECT | total electrical energy input (ie. circulation fan, exhuast fan, and thermostat circuit) to the furnace over the specified period (megajoules ) |
| TOTAL | total energy input to the furnace (gas + electrical) |
| DD | degree days; representing the number of degrees the mean daily temperature is below 18 Deg. C., totalled over the test period. |
| AVG. MEAN | weekly average mean daily outdoor temperatures (deg. C), this is not to be confused with average daily temperatures (ie. sum of daily mean temps./7) |
| ***** | NOTE- in all instances, mean refers to the arithmetic mean ((max.-min.)/2) and not an average (total/#in total) |

### 3.2 CONSUMPTION FIGURES

As a graphical representaton, figures 1 thru 4 illustrate the respective energy consumptions as a function of both the weekly DD and the weekly average mean daily outdoor temperatures. In each instance, the data was fitted using a least squares linear regression; each of which had a correlation factor of 0.97 or better. From these results one may be quite confident in the data as it is relatively accurate and shows good correlation.

## TABLE 1

SITE I (GAS/GAS)
CONVENTIONAL FURNACE

| Period (incl.) | Gas (MJ) | Elect (MJ) | Total (MJ) | DD (18 C) | Avg. Mean Temp. (Deg. C) |
|---|---|---|---|---|---|
| 06-12/12/82 | 2072.79 | 104.37 | 2177.16 | 135.9 | -1.41 |
| 20-26/12/82 | 1513.71 | 50.38 | 1564.10 | 100.4 | 3.66 |
| 03-09/01/83 | 2278.48 | 64.78 | 2343.26 | 129.8 | -0.54 |
| 17-23/01/83 | 3314.87 | 125.97 | 3440.84 | 170.6 | -6.37 |
| 31-06/02/83 | 2995.78 | 82.78 | 3078.56 | 148.0 | -3.14 |
| 14-20/02/83 | 1830.17 | 53.99 | 1884.16 | 109.5 | 2.36 |
| 28-06/03/83 | 1260.55 | 35.99 | 1296.53 | 87.9 | 5.44 |
| 14-20/03/83 | 1421.41 | 39.59 | 1461.00 | 95.6 | 4.34 |
| 28-03/04/83 | 1925.15 | 50.39 | 1975.54 | 115.2 | 1.54 |
| 11-17/04/83 | 1218.35 | 32.39 | 1250.74 | 92.5 | 4.79 |
| 25-01/05/83 | 680.38 | 21.60 | 701.98 | 55.0 | 10.14 |
| Totals | 20511.65 | 662.22 | 21173.87 | 1240.4 | |

Total Energy per Degree Day=17.07 MJ/DD

## TABLE 2

SITE I (GAS/GAS)
CONDENSING FURNACE

| Period (incl.) | Gas (MJ) | Elect (MJ) | Total (MJ) | DD (18 C) | Avg. Mean Temp. (Deg. C) |
|---|---|---|---|---|---|
| 29-05/12/82 | 392.93 | 32.39 | 425.32 | 54.9 | 10.16 |
| 13-19/12/82 | 1395.04 | 79.18 | 1474.22 | 124.2 | 0.26 |
| 27-02/01/83 | 1550.63 | 97.17 | 1647.81 | 123.4 | 0.37 |
| 10-16/01/83 | 2027.95 | 104.37 | 2132.32 | 144.5 | -2.64 |
| 24-30/01/83 | 1983.12 | 68.39 | 2051.51 | 142.5 | -2.36 |
| 07-13/02/83 | 2362.87 | 111.57 | 2474.44 | 178.4 | -7.49 |
| 21-27/02/83 | 1729.96 | 100.77 | 1830.73 | 128.6 | -0.37 |
| 07-13/03/83 | 1205.69 | 64.78 | 1270.47 | 97.8 | 4.03 |
| 21-27/03/83 | 2101.79 | 115.17 | 2216.96 | 151.6 | -3.66 |
| 04-10/04/83 | 941.46 | 50.39 | 991.85 | 88.9 | 5.30 |
| 18-24/04/83 | 1176.16 | 64.79 | 1240.95 | 102.7 | 3.33 |
| Totals | 16867.62 | 888.97 | 17756.59 | | 1337.5 |

Total Energy per Degree Day=13.28 MJ/DD

## TABLE 3

SITE II (OIL/GAS)
CONVENTIONAL FURNACE

| Period (incl.) | Oil (MJ) | Elect (MJ) | Total (MJ) | DD (18 C) | Avg. Mean Temp. (Deg. C) |
|---|---|---|---|---|---|
| 07-13/12/82 | 12650.58 | 161.97 | 12812.54 | 147.7 | -3.10 |
| 21-27/12/82 | 9537.98 | 125.97 | 9663.95 | 94.6 | 4.49 |
| 04-10/01/83 | 11876.06 | 154.77 | 12030.82 | 121.7 | 0.61 |
| 18-24/01/83 | 15133.70 | 176.35 | 15310.06 | 160.1 | -4.87 |
| 01-07/02/83 | 13834.12 | 169.17 | 14003.29 | 150.7 | -3.53 |
| 15-21/02/83 | 9542.33 | 122.38 | 9664.70 | 105.7 | 2.90 |
| 01-07/03/83 | 7297.07 | 100.78 | 7397.85 | 81.4 | 6.37 |
| 12-21/03/83 | 10663.65 | 133.53 | 10797.17 | 150.6 | 2.94 |
| 29-04/04/83 | 10007.91 | 125.97 | 10133.88 | 113.7 | 1.76 |
| 12-18/04/83 | 9904.93 | 125.97 | 10030.90 | 101.0 | 3.57 |
| 26-03/05/83 | 6183.15 | 86.38 | 6269.53 | 54.8 | 11.15 |
| Totals | 116631.49 | 1483.25 | 118114.72 | 1387.7 | |

Total Energy per Degree Day=85.12 MJ/DD

** Data corrected for 7 day period.

## TABLE 4

SITE II (OIL/GAS)
CONDENSING FURNACE

| Period (incl.) | Gas (MJ) | Elect (MJ) | Total (MJ) | DD (18 C) | Avg. Mean Temp. (Deg. C) |
|---|---|---|---|---|---|
| 30-06/12/82 | 2605.49 | 125.97 | 2731.46 | 53.4 | 10.37 |
| 14-20/12/82 | 5358.65 | 230.34 | 5588.99 | 118.7 | 1.04 |
| 28-03/01/83 | 5485.23 | 230.34 | 5715.57 | 131.2 | -0.74 |
| 11-17/01/83 | 6719.41 | 277.13 | 6996.54 | 160.3 | -4.90 |
| 25-31/01/83 | 6012.66 | 266.34 | 6279.00 | 143.8 | -2.54 |
| 08-14/02/83 | 6255.27 | 262.73 | 6518.01 | 175.9 | -7.13 |
| 22-28/02/83 | 5221.52 | 241.15 | 5462.67 | 127.1 | -0.16 |
| 08-11/03/83 | 4301.17 | 207.85 | 4520.32 | 57.4 | 3.65 |
| 22-28/03/83 | 5938.82 | 244.74 | 6183.56 | 145.6 | -2.80 |
| 05-11/04/83 | 3976.79 | 194.35 | 4171.14 | 86.9 | 5.59 |
| 19-25/04/83 | 4187.76 | 187.16 | 4374.92 | 94.7 | 4.47 |
| Totals | 56062.76 | 2468.11 | 58530.87 | 1295.0 | |

Total Energy per Degree Day=45.20 MJ/DD

** Data corrected for 7 day period

## 3.3 CONSUMPTION ANALYSIS

From fig.1, representing a smaller home with a modest heat loss (Site I), one can appreciate the increase in total energy savings with the increase in degree days. This in itself is interesting as it suggests that substantial savings may be realized primarily during the colder weather. Clearly, the relative savings of the condensing furnace appears constant (as a percentage), as may not have been previously assumed. As well, these curves suggest a definite reversal in savings during the warmer weather. It is important however to realize here the tolerences associated in establishing the consumption curves. Although the data itself shows good linear correlation, there remain several factors which are undetermined. Primarily, concern exists as to the infiltration, internal gains and solar effects, each of which were not monitored and are generally very difficult to establish. Clearly, particular caution must be taken in concluding results at the lower degree days (warmer weather) where the graphs are especially sensitive and subject to large tolerences, as very few monitoring points are available at these conditions. For this reason, it is very difficult to predict actual savings and performance levels at these higher outdoor temperatures.

In determining the load characteristics of the equipment with respect to ambient temperatures, Fig. 2 illustrates the test results as derived from Fig. 1. Again, there is an apparent reversal in savings at warmer temperatures. In a similar argument as for Fig. 1, Fig. 2 is highly dependent on solar, internal and infiltration effects. As such, it is again difficult to draw conclusive results at the higher temperatures where the data is limited. In addition, the set point conditions must be considered when investigating balance point performance. For these reasons, care must be taken in deriving balance point information from these graphs. Although the balance points themselves appear correct in that they are at or about the right temperatures for this construction, it must be remembered that they are not to be taken as absolutes.

Similar to Fig. 1 in content, Fig. 3 illustrates the total energy savings during operation of the oil/gas site. Again this is interesting in that it suggests there is no reduction in savings as a function of ambient conditions, given that the relative savings are constant. One may also notice that at zero degree days there is still a heating requirement; suggesting 1) that the house may not have the balance point as assummed in deteriming the degree days (18 C) and; 2) that again solar, infiltration and internal effects are significant.

With Fig. 4, savings are again experienced with the condensing furnace as a function of ambient temperatures. Similar to Fig. 2, there appears to be a reversing of efficiencies at the higher temperatures. Again, diffi-

culty appears to exist with the unknown load variables. Notwithstanding, it is again possible to comment as to the apparent balance point temperatures. Although it is difficult to establish absolute balance point conditions, it is possible to conclude that these values are generally accurate (within the allowable tolerences of the data). Perhaps high however as compared to Site I, with a balance point of 12 to 15 C, a balance point of 20-22 C for this house is not unrealistic given the design of the home (ranch style over an unheated crawlspace with large wind exposures) , its set point (22 Deg. C.) and the garage location of the furnace.

In establishing the total demands of the different furnaces, it became apparent that the electrical requirements of the equipment is relatively constant as a percentage of the fuel used. At the oil site, the electricity to fuel ratio was typically 1.30 and 4.40% for the oil and condensing gas furnaces respectively. Similarly, the gas/gas site had electricity percentages of 3.20 and 5.30% of the gas used for the conventional and condensing gas furnaces.

Finally, Tables 5A & 5B summarize the actual energy savings as experienced throughout the test period. Total energy savings of nominally 22 and 47% were found using the condensing gas furnaces at sites I and II (Gas/Gas, Oil/Gas) respectively. It should be remembered however that these figures are based on information gathered over only approximately one third of the normal heating season (in terms of the actual DD experienced per furnace).

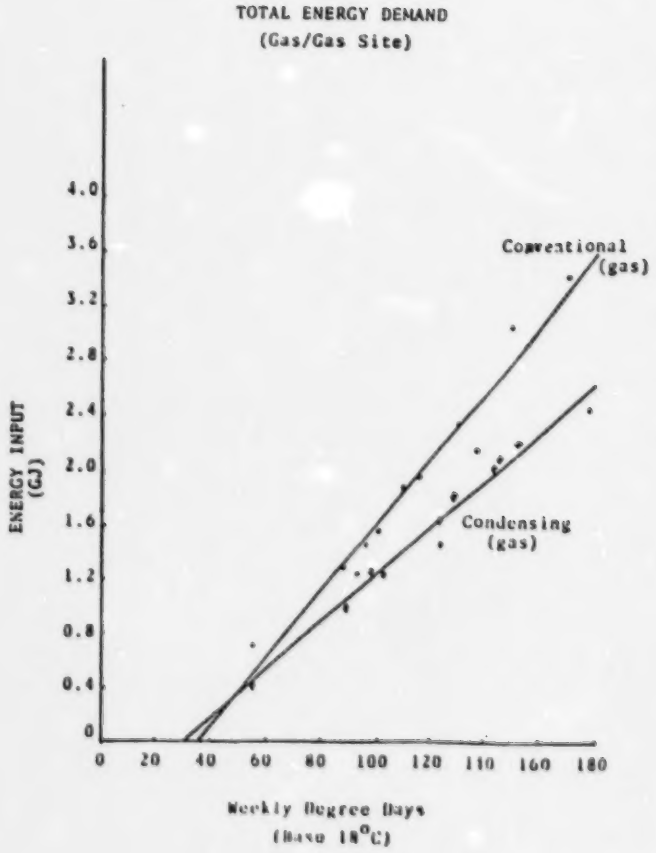
TOTAL ENERGY DEMAND
(Gas/Gas Site)
ENERGY INPUT
(GJ)
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
Conventional
(gas)
Condensing
(gas)
0 20 40 60 80 100 120 110 160 180
Weekly Degree Days
(Base 18°C)

Fig. 1

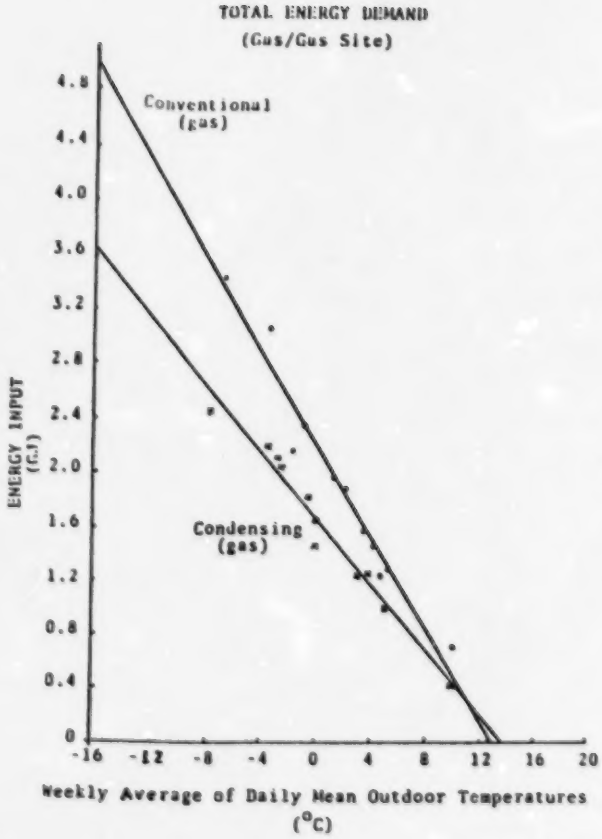
TOTAL ENERGY DEMAND
(Gas/Gas Site)
ENERGY INPUT
(G.J.)
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
Conventional
(gas)
Condensing
(gas)
-16 -12 -8 -4 0 4 8 12 16 20
Weekly Average of Daily Mean Outdoor Temperatures
(°C)

Fig. 2

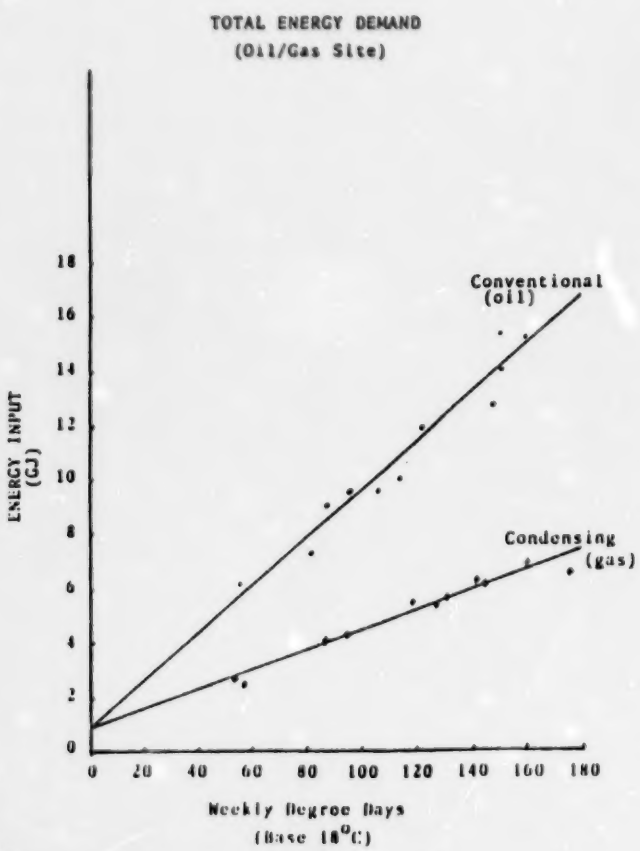
TOTAL ENERGY DEMAND
(Oil/Gas Site)
ENERGY INPUT
(GJ)
0
2
4
6
8
10
12
14
16
18
Conventional
(oil)
Condensing
(gas)
0
20
40
60
80
100
120
140
160
180
Weekly Degree Days
(Base 18°C)

Fig. 3

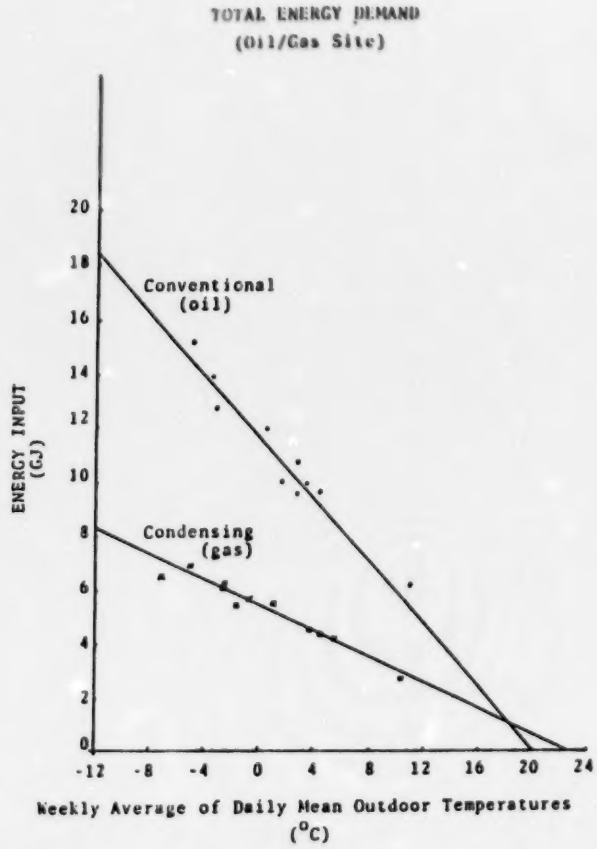
TOTAL ENERGY DEMAND
(Oil/Gas Site)
ENERGY INPUT
(GJ)
0
2
4
6
8
10
12
14
16
18
20
Conventional
(oil)
Condensing
(gas)
-12
-8
-4
0
4
8
12
16
20
24
Weekly Average of Daily Mean Outdoor Temperatures
(°C)

Fig. 4

## TABLE 5A

TEST RESULTS

| | ENERGY CONSUMPTION (MJ/DD) | | | ENERGY RATIO | % SAVINGS IN ENERGY/DD | | |
|---|---|---|---|---|---|---|---|
| | Elect. | Fuel | Total | (Elect./Fuel) | Elect. | Fuel | Total |
| **SITE I** | | | | | | | |
| Conv. Furn. | 0.53 | 16.54 | 17.07 | 0.032 | | | |
| Cond. Furn. | 0.67 | 12.61 | 13.28 | 0.053 | -26.42 | 23.76 | 22.2 |
| **SITE II** | | | | | | | |
| Conv. Furn. | 1.07 | 84.05 | 85.12 | 0.013 | | | |
| Cond. Furn. | 1.91 | 43.29 | 45.20 | 0.044 | -78.5 | 48.50 | 46.90 |

## TABLE 5B

TEST SAVINGS

| | Real Savings In MJ/DD | | |
|---|---|---|---|
| | Elect. | Fuel | Total |
| **SITE I** | | | |
| Condensing Furnace | -0.14 | 3.93 | 3.79 |
| **SITE II** | | | |
| Condensing Furnace | -0.84 | 40.76 | 39.92 |

## 4.0 ECONOMIC ANALYSIS

### 4.1 ENERGY COST SAVINGS

Although, as previously mentioned, the actual study only covers approximatly a third of the heating season per appliance, it is still possible to estimate annual savings based on these results. In addition, the good linear correlation of the data can assure a certain degree of confidence in the findings.

With projected consumption histories from figs. 1 and 3, annual energy estimates have been calculated and are presented in Tables 6 and 7 (Page 15 and 16). Based on 30 year averages of monthly degree days, this information should represent a good approximation of the yearly energy requirements. Table 8 summarizes these results, both in terms of total consumption and percent savings. Generally, one can see a total savings of 24 and 49% at the gas and oil sites respectively. In terms of real dollars, this represents savings of $73 and $1,550 for the gas and oil sites respectively. Table 9 summarizes these results. As throughout this report, all dollar figures are in current 1983 dollars; with gas, oil and electricity at an end price of 0.2127 $/cu.m, 0.302 $/L and 0.039 $/KWH respectively. All rates are as of April '83 as found in the Chatham area, and represent rates at which they are most likely to be charged (ie. fixed charge and first block for gas and second block for electricity).

In concluding, Table 10 is presented to illustrate estimated annual cost comparisons given conventional and condensing natural gas, oil and electric heating. From these figures, one can see that the condensing gas furnace was consistantly the least expensive to operate. With these comparisons, one must appreciate however that there is a combined effect in moving between fuels. Aside from the efficiency differences, there is also the cost per unit of energy as associated with the various fuels.

Finally, Table 11 illustrates an estimated life cycle cost analysis of the various options as presented in Table 10. From these results, one can again see that the condensing gas furnace is a very significant alternative. In each instance, the condensing natural gas furnace had the lowest fifteen year discounted cost.

## TABLE 6

PROJECTED CONSUMPTION
(SITE I)

| Month | Monthly Degree Days | Conventional Monthly | | Condensing Monthly | |
|---|---|---|---|---|---|
| | | Gas (GJ) | Elect. (GJ) | Gas (GJ) | Elect. (GJ) |
| J | 678.9 | 12.54 | 0.37 | 9.16 | 0.50 |
| F | 620.6 | 11.50 | 0.35 | 8.40 | 0.45 |
| M | 520.8 | 8.77 | 0.26 | 6.49 | 0.35 |
| A | 303 | 3.69 | 0.11 | 2.88 | 0.16 |
| O | 192.2 | 0.93 | 0.03 | 0.94 | 0.05 |
| N | 396 | 5.91 | 0.18 | 4.46 | 0.24 |
| D | 613.8 | 10.99 | 0.33 | 8.06 | 0.44 |
| Totals | 3325.30 | 54.32 | 1.63 | 40.39 | 2.18 |

## TABLE 7

PROJECTED CONSUMPTION
(SITE II)

| Month | Monthly Degree Days | Conventional Monthly | | Condensing Monthly | |
|---|---|---|---|---|---|
| | | Oil (GJ) | Elect. (GJ) | Gas (GJ) | Elect. (GJ) |
| J | 678.9 | 58.98 | 0.77 | 27.00 | 1.21 |
| F | 620.6 | 53.81 | 0.71 | 24.59 | 1.10 |
| M | 520.8 | 47.33 | 0.62 | 22.56 | 1.01 |
| A | 303 | 31.00 | 0.41 | 16.19 | 0.73 |
| M | 127.1 | 18.32 | 0.24 | 11.51 | 0.52 |
| O | 192.2 | 23.12 | 0.30 | 13.33 | 0.60 |
| N | 396 | 37.85 | 0.50 | 18.80 | 0.84 |
| D | 613.8 | 54.18 | 0.71 | 25.17 | 1.13 |
| Totals | 3452.4 | 324.60 | 4.25 | 159.5 | 7.13 |

## TABLE 8

PROJECTED
ANNUAL RESULTS

| | Annual Energy Consumption (GJ) | | | Annual % Savings in Energy | | |
|---|---|---|---|---|---|---|
| | Elect. | Fuel | Total | Elect. | Fuel | Total |
| **SITE I** | | | | | | |
| Conv. Furn. | 1.63 | 54.32 | 55.95 | | | |
| Cond. Furn. | 2.19 | 40.39 | 42.58 | -34.36 | 25.64 | 23.90 |
| **SITE II** | | | | | | |
| Conv. Furn. | 4.25 | 324.60 | 328.85 | | | |
| Cond. Furn. | 7.13 | 159.15 | 166.28 | -67.77 | 50.97 | 49.44 |

## TABLE 9

PROJECTED YEARLY SAVINGS

| | Gas/Gas | Oil/Gas |
|---|---|---|
| **Fuel** | | |
| (GJ) | 13.92 | 165.45 |
| | $79.10 | $1581.30 |
| **Electric** | | |
| (KWH) | -153.30 | -799.50 |
| | $ -5.98 | $ -31.18 |
| **TOTAL ANNUAL SAVINGS** | $73.12 | $1550.12 |

## TABLE 10

### ESTIMATED ANNUAL ENERGY COMPARISONS

| | Oil | Conventional Gas | Condensing Gas | Electric |
|---|---|---|---|---|
| **Gas/Gas** | | | | |
| GJ | 56.79 | 55.95 | 42.58 | 38.05 |
| Effic. | 0.67 | 0.68* | 0.89* | 1.00 |
| $ | 450 | 402 | 329 | 412 |
| **Oil/Gas** | | | | |
| GJ | 328.85 | 218.48 | 166.28 | 142.04 |
| Effic. | 0.40* | 0.60 | 0.79* | 0.93 |
| $ | 2600 | 1350 | 1060 | 1540 |

**NOTES**

1. Efficiencies are approximate in that assumed values are used; relative efficiency differences are however correct for the units under test.

2. Efficiencies are reduced at oil site based on garage location of furnaces and ducting in the unheated crawl space. Other conditions of note (1) also apply.

3. Based on current rates and schedules.

* Based on relative efficiency differences as established by this study.

## TABLE 11

15 YEAR DISCOUNTED COST*
($)

| | Oil | Conventional Gas | Condensing Gas | Electric |
|---|---|---|---|---|
| Gas/Gas Site | 6269 | 5734 | 5650 | 6578 |
| Oil/Gas Site | 32649 | 16933 | 14253 | 18429 |

* Based on the procedures and assumptions as outlined in Reference 2. The respective system consumptions and efficiencies, were as determined by this study (Table 10). The actual service life of the gas equipment may easily be greater than fifteen years (ie. 20 yrs.); thereby improving their cost advantage.

## 5.0 CONCLUDING RESULTS

### 5.1 RESULTS

From the information as presented above, it is apparent that there is a real savings to be achieved with the condensing gas furnaces. These savings were realized both in terms of total energy and money. The gas/gas site for example had a projected total annual energy savings of approximately 372 cu. m. (24%) or $73. This can be compared to the 49% (4312 l) or $1550 annual savings as suggested with the oil site.

At both locations, the new condensing furnaces operated very satisfactorily, with only a very minor increase in installation requirements and cost.

### 5.2 CONCLUSIONS

Although there appear to be significant savings to be gained with condensing gas furnaces, one must be aware of several important issues:

1. In both installations, it is very difficult to draw conclusive results from the ambient temperature intercepts of Figs. 3 and 4 (ie. balance points). Nevertheless, the general savings as indicated by the load curves can be used with relative confidence. As the balance points are a derived condition from the ambient temperature intercepts, there remains a reasonable degree of uncertainty as to their absolute value. This uncertainty lies in the unresolved tolerences of the data as effected by environmental conditions and occupancy patterns. To accurately determine balance point conditions would require a much more extensive study.

2. Only one third of a normal heating season was typically covered on each appliance. A longer test period may reveal previously undetected operating difficulties with the new equipment.

3. The condensing furnaces have shown to be 31 and 98% nominally more seasonally efficient than the conventional gas and oil furnaces respectively.

4. The 31% seasonal improvement in gas heating efficiency appears to be in line with both the manufacturers claims and theoretical estimates. This improvement in efficiency would give a condensing furnace a seasonal rating of some 89% (assuming a conventional seasonal efficiency of 60-68%).

5. With an apparent increase of 98% in seasonal efficiency as compared to the conventional oil, one would expect the gas furnace to be nearly 125% efficient (given a conventional oil furnace at 60-65%). This however is impossible. One can only suggest that the conventional furnace is heating somewhat below the normally assumed 60-65% figure due to its location, and the location of the distribution system (in an unheated crawl space). A more realistic figure would be 40% for the existing oil installation. It is strongly recommended that the results of the oil site NOT be generalized to cover other oil installations.

6. No attempt was made to force the results through a common balance point as there appears to be no basis to do so. In each instance, the respective balance points are within the tolerence limits of the study results.

7. All prices and savings are of course subject to current rates and as such can not be guaranteed. Clearly, increased electrical rates will reduce the dollar savings of the condensing furnace as compared with the conventional units.

## REFERENCES


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